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correction of the elements of the orbit of Halley's Comet. (Appendices to various *Nautical Almanacs*, p. 196.)

Thus to find $\frac{d\varpi}{dV}$ for any star, increase V by unity, and recompute; this will give the change in ϖ corresponding to a change of $+1$ in V, or approximately $\frac{d\varpi}{dV}$.

Similarly, $\frac{d\varpi}{d\Lambda}$ and $\frac{d\varpi}{d\Pi}$ may be found.

But instead of finding $\frac{d\varpi}{d\lambda}$, &c., we must increase the apex 1° in R.A., the N.P.D. being unchanged; and by computing the new λ and μ, and the new ϖ, we get $\frac{d\varpi}{da}$. Similarly by increasing the apex 1° in N.P.D., the R.A. remaining unchanged, and by computing the new λ, μ, and ν, and the new ϖ, we get $\frac{d\varpi}{d\beta}$.

And similarly we must treat the position of the Sun as seen from the Centre, and get $\frac{d\varpi}{d\mathit{Æ}}$ and $\frac{d\varpi}{d\Delta}$.

Of course, the same computations will apply to a system of corrections based upon radial velocity as well as upon parallax. And then from the two systems we get equations similar to

$$\mathfrak{A} \,.\, \Delta\lambda + \mathfrak{B} \,.\, \Delta\mu + \&c. \ + \Delta\varpi = 0$$

$$\mathfrak{A} \,.\, \Delta\lambda + \mathfrak{B} \,.\, \Delta\mu + \&c. \ + \Delta\frac{d\rho}{dt} = 0,$$

where $\Delta\lambda$, $\Delta\mu$, &c., are the corrections to be applied to the assumed values of λ, μ, &c., and where $\Delta\varpi$ is the observed minus the computed parallax, and where $\Delta\frac{d\rho}{dt}$ is the observed minus the computed radial velocity.

Jamaica:
1898 *June* 2.

Observations of Jupiter in 1898. By W. F. Denning.

During the period from 1898 March to July I observed *Jupiter* on 51 nights in my 10-inch Browning-With reflector. I usually employed one of Steinheil's "monocentric oculars," consisting of three cemented lenses and giving a power of 312. Occasionally I used the single lens of a Huygenian magnifying 252, and more rarely one of Browning's achromatic eye-pieces with a power of 488. But, ordinarily, the power of 312 possessed a marked advantage over the others.

I obtained about 280 estimated transits of the various markings on the planet, with a view to finding the individual

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velocities of the currents in which they were situated. The results for each object observed are given in a tabular form at the end of this paper. About eight different currents were manifested, of which the following is a summary:—

Approx. Latitude.	Number of Objects seen.	Description of Objects.	Period of Rotation.		
°			h	m	s
+39	1	Dark oval spot on NN. temp. belt	9	55	47·8
+33	1	Dark oval spot in bright zone	9	55	52·5
+15	3	Dark oval spots	9	55	26·3
Region of Equator	23	Dark and white spots	9	50	23·6
−21	1	Great red spot	9	55	41·8
−30	4	Dark and white spots on S. temp. belt	9	55	20·5
−35	2	White spots in zone S. of preceding	9	55	14·0
−40	2	Dark spots	9	55	8·6

The latitudes are by estimation. It is possible that the first two objects may represent one current only, the difference in their rotation periods being less than 5 seconds. It is noteworthy that these objects in the N. hemisphere were the only ones observed which were moving more slowly than the great red spot. The spot in Lat. +39°, which was really a swell or thickening in the NN. temp. belt, could not be followed after May 23; it had lengthened out, and its material appeared to be in process of distribution along the belt. The oval spot in Lat. +33° survived until early in July, when, however, it was seen with difficulty.

With reference to the equatorial spots, they were so numerous, subject to so many variations in form and distinctness, and influenced by such different, and apparently irregular, velocities, that it was often hard to identify the same objects with certainty. The 23 markings included in the table are chiefly selected as being the most conspicuous of their class, and affording satisfactory means of identification. It will be observed, on comparing the rotation periods for the individual spots in this current, that the motion was far from being equable, and that it exhibited large discordances in different longitudes. The extremes were those of a dark spot (No. 3) in $\lambda 29^\circ{\cdot}2$ on June 11, rotation period $9^h\ 50^m\ 33^s{\cdot}2$, and of a similar spot (No. 19) in $\lambda 300^\circ{\cdot}5$ on May 8, rotation period $9^h\ 50^m\ 16^s{\cdot}9$. The numerous other objects circulating along this region presented a variety of periods between the extremes mentioned. This difference in relative velocities induced some complications of a puzzling character, for it enabled certain spots to overtake and pass others moving at slower rates. Thus No. 11 in the table of equatorial spots was east of No. 10 in April, but apparently passed it in May, and was afterwards placed on its western side. No. 23 may be regarded as a special object, inasmuch as it was situated on the N. equatorial belt, but it moved at about the same rate as that shown by a mean of all the other equatorial spots in the table which were placed on the N. side of the S. equatorial belt.

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The mean rotation period of 9^h 50^m 23^s·6 is 6^s·4 shorter than the adopted period (9^h 50^m 30^s) on which system I. in the ephemerides is based. It proves that the velocity of the equatorial current of *Jupiter* received considerable acceleration between the spring of 1897 and that of 1898. From 8 spots observed at the former season Mr. A. Stanley Williams deduced a mean rotation period of 9^h 50^m 34^s·6 (*Monthly Notices*, 1897 November, p. 13), which is exactly 11 seconds greater than the mean of my own observations in 1898. It would appear, therefore, that the equatorial current, after slackening from 9^h 50^m in 1879 to 9^h 50^m 34^s·6 in 1897, has now markedly increased its rate. This has varied as follows, according to previous observations here:—

	h	m	s
1880	9	50	5·8
1881	9	50	8·8
1882	9	50	11·4
1885	9	50	14·3
1886	9	50	22·8
1895	9	50	34·3
1898	9	50	23·6

As to the great red spot, it has recently been exceedingly faint. The *f* side was the plainest, but the complete oval outline of this marking was distinctly seen on but one occasion this year, when the image was beautifully defined and very steady. On March 22, and on a few subsequent occasions when fairly good glimpses were obtained, I remarked that the red spot did not appear to be symmetrically placed within the dip or bay in the S. side of the S. equatorial belt. The W. side or *p* shoulder of the bay was, however, flatter than the E. side, and moreover there was a very bright streak curving round the N. *p* side of the spot, and extending from that region to the planet's W. limb. This would naturally induce the impression that the spot was a little E. of the centre; I believe, however, even though the circumstances favoured a mistaken view, that the spot decidedly leaned to the *f* side, and the Rev. T. E. R. Phillips, of Yeovil, noticed the same thing on several occasions.

This configuration is not new, for it was noticed here on various nights during the oppositions of 1895 and 1897, but particular attention was not paid to it. It is a point which can only be settled by micrometric measurements, but the present extremely feeble aspect of this marking must render these very difficult. The motion of the spot appears to have further slackened, but only in a slight degree. In July the middle of the spot was in λ 28°, so that it was seen at mid-transit 46 minutes after the passage of the zero meridian of System II. in Mr. Crommelin's ephemerides (*Monthly Notices*, 1898 April). The values referred to (λ 28°=46^m) represent the cumulative effect of the difference between the rate of motion of the red spot and the period of 9^h 55^m 40^s·63, upon which System II. is

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based, since the summer of 1894, when the position of the red spot coincided with that of the zero meridian. In point of fact, the mean rotation period of the spot during the four years (nearly) from 1894 August 10 to 1898 July 30 (3,504 rotations) was $9^h\ 55^m\ 41^s{\cdot}4$, or $0^s{\cdot}78$ greater than the period adopted in System II.

There were visible three dark, elongated spots,* just exterior to the N. equatorial belt, and situated on a very delicate, narrow belt, in about Lat. +15°. These rotated at an average rate of 15½ seconds less than that of the red spot at the same period. Relatively to the position of the latter these markings would, therefore, complete a revolution round *Jupiter* in 954 days, while the equatorial spots have recently occupied only 46½ days. S. of the *f* ends of the three objects alluded to, and touching the N. side of the N. equatorial belt, there were bright spots which maintained their positions, and were at times strikingly brilliant. The *p* ends of the dark spots sometimes appeared bent abruptly to S., and in actual contact with the equatorial belt, but when definition was good the junction could not be confirmed, and the impression of its existence seemed due to the fact that the bright spots at the *f* ends intensified the division in that part, while the more dusky space between the *p* ends and the belt brought about the apparent coalescence of the objects, especially on a night when definition was indifferent.

The white and dark spots in Lat. −30° seem to have changed their rate of motion very little, if at all, from that observed in previous years, when the rotation period was about $9^h\ 55^m\ 18^s$. Further south the spots are influenced by a much swifter current, but they are subject to such variations, and often nearly obliterated by inferior definition, that it is difficult to secure a sufficient number of really accurate observations to enable their exact periods to be ascertained. Quite possibly the two pairs of spots, in Lat. −35° and −40° respectively, may be situated in the same current, with a mean period of about $9^h\ 55^m\ 11^s$.

In determining the rotation periods in the following table I have compared two or three of the earliest with a similar number of the latest transits of the same object when the observations were sufficiently numerous for that purpose. In cases where a spot was observed for position on very few occasions, the first and last transits were utilised, and, in deriving the results, the more doubtful observations were rejected. The longitudes of the spots exterior to the equatorial belts were computed with reference to the zero meridian of System II., and the longitudes of the equatorial spots were based on System I. of Mr. Crommelin's ephemerides in *Monthly Notices*, 1897 November and 1898 January.

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* Several additional markings of similar character and position were seen early in the opposition by Herr Fauth at Landstuhl, and at a later period by Mr. A. Stanley Williams at Brighton. The three objects observed at Bristol appear, however, to have been the most conspicuous and durable, and to have attracted the notice of a large number of observers.

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Rotation Periods of Markings Outside the Equatorial Region of Jupiter, 1898.

No.	Description of Object.	Approximate Latitude.	Mean Longitude.	Mean Date.	Whole Period of Observation.		Length of Interval.	Rotations.	Period of Rotation.	No
					h m	h m	d h m		h m s	
1	Dark oval spot on belt	+39°	285°·8	May 5	April 17, 9 18	May 23, 9 14	35 23 56	101	9 55 47·8	1
2	Dark oval spot in bright zone . . .	+33	280·9	May 20	April 7, 10 39	July 3, 8 22	86 21 43	210	9 55 52·5	2
3	Dark oval spot	+15	110·8	May 13	Mar. 23, 9 25	July 4, 8 40	102 23 15	249	9 55 27·7	3
4	,, ...	+15	238·4	June 1	April 17, 8 32	July 17, 8 1	90 23 29	220	9 55 26·3	4
5	,, ...	+15	287·3	May 15	Mar. 14, 12 5	July 17, 9 10	124 21 5	302	9 55 24·8	5
6	Great red spot	−21	26·8	May 26	Mar. 22, 10 43	July 30, 8 29	129 21 28	314	9 55 41·8	6
7	White spot on S. temp. belt . . .	−30	1·8	May 11	April 15, 10 12	June 7, 8 20	52 22 8	128	9 55 21·7	7
8	,, ,, ,, ...	−30	11·7	June 1	May 14, 9 18	June 19, 8 40	35 23 21	87	9 55 21·6	8
9	,, ,, ,, ...	−30	127·9	May 13	April 4, 9 53	June 22, 9 3	78 23 10	191	9 55 19·4	9
10	Dark mass on S. temp. belt	−30	137·9	June 8	May 15, 8 46	July 2, 7 51	47 23 5	116	9 55 19·5	10
11	White spot in zone S. of S. temp. belt	−35	157·7	April 24	April 4, 10 30	May 15, 8 36	40 22 6	99	9 55 14·4	11
12	,, ,, ,,	−35	297·0	May 25	April 22, 9 25	June 28, 8 43	66 23 18	154	9 55 13·7	12
13	Dark ellipse	−40	126·5	May 19	April 16, 9 57	June 22, 8 47	66 22 50	154	9 55 9·5	13
14	Dark spot	−40	291·9	May 29	April 22, 9 25	July 5, 9 13	73 23 48	179	9 55 7·7	14

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Notes.

1. This object was seen by Dr. A. A. Nijland, of Utrecht, on April 5, in λ 289° Lat. +38° (*Ast. Nach.* 3488). It was not definitely recorded after May 23, having dispersed itself along a dusky belt.

2. Ten observations were obtained. The spot gradually became faint, and could not be seen at the middle of July. The Rev. T. E. R. Phillips obtained the place of this object on March 21 as λ 265°·5, and March 28 λ 267°·7. Dr. Nijland saw it on April 5 and found it in λ 272°, Lat. +31°. This object, and the preceding, are shown on a planisphere of *Jupiter* (opposition of 1898) by Signer J. Comas Solà, in *Ast. Nach.* 3,519. He, however, depicts the markings as having a more strikingly beaded or knotted aspect than was observed here.

3. Nine observations. Spot apparently first seen by Brenner on January 20 in λ 144°·5 (*Ast. Nach.* 3476).

4 and 5. These spots were recorded by Fauth as early as 1897 Nov. 25 in λ 305° and 360° (*Ast. Nach.* 3488). I obtained seven observations of No. 4 and seventeen of No. 5. The former was much the smaller of the pair, and could not be seen at all on nights of bad definition.

6. This object was extremely faint, and its elliptical contour usually quite indeterminate. It would often entirely escape notice but for the depression in the S. equatorial belt which guides the eye to its position. The southern boundary of the spot was fringed with dark material, apparently by coalescence with the N. side of the S. temperate dusky belt.

7. Six observations. This marking was in conjunction with the red spot on about March 23.

8. Only three observations were obtained. Conjunction with the red spot occurred on May 10, and it was very bright at about this time with a luminous trail running some distance to S.E.

9 and 10. These showed a period 2^{s} less than Nos. 7 and 8, but the difference may have arisen either from errors of observation or from a real inconsistency in the rate of motion of the various objects.

11, 12, 13, and 14. Eight observations were obtained of No. 14, but very few of the others. Reliable transits could only be secured when the definition was very good. Early in July No. 14 appeared to have lost its definite character and to have distended itself along a dusky belt on its southern borders. No. 13 appears to have been first seen by the Rev. T. E. R. Phillips at Yeovil on March 23, and for several months it remained a remarkably definite object.

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Rotation Periods of Equatorial Spots on Jupiter, 1898.

No.	Spot.	Mean Longitude of Spot.	Mean Date.	Whole Period of Observation.	h	m		h	m	Length of Interval. d	h	m	Rotations.	Period of Rotation. h	m	s	No.
1	D	0°·1	July 9	June 19,	7	50	July 30,	8	11	41	0	21	100	9	50	28·9	1
2	W	18·5	June 11	May 18,	8	39	July 5,	8	9	47	23	30	117	9	50	26·1	2
3	D	29·2	June 11	May 18,	8	49	July 5,	8	34	47	23	45	117	9	50	33·2	3
4	D	62·2	May 13	Mar. 22,	10	15	July 5,	9	2	104	22	47	256	9	50	19·5	4
5	W	73·0	May 24	April 7,	10	14	July 10,	7	30	93	21	16	229	9	50	19·6	5
6	D	87·3	May 27	April 7,	10	31	July 17,	7	33	100	21	2	246	9	50	24·7	6
7	D	120·4	May 27	April 7,	11	26	July 17,	8	17	100	20	51	246	9	50	24·4	7
8	W	143·0	May 30	April 12,	10	4	July 17,	8	58	95	22	54	234	9	50	26·1	8
9	D	154·1	May 23	April 1,	8	36	July 15,	8	8	104	23	32	256	9	50	28·0	9
10	W	208·8	April 28	April 15,	8	39	May 12,	10	8	27	1	29	66	9	50	27·5	10
11	D	207·3	May 29	April 15,	8	54	July 13,	8	6	88	23	12	217	9	50	17·9	11
12	W	212·8	June 3	April 24,	9	26	July 13,	8	22	79	22	56	195	9	50	22·9	12
13	D	221·1	June 12	May 12,	10	34	July 13,	8	43	61	22	9	151	9	50	26·6	13
14	D	236·9	May 25	April 24,	10	0	June 25,	8	0	61	22	0	151	9	50	25·2	14
15	W	260·6	May 15	April 4,	8	41	June 25,	8	26	81	23	45	200	9	50	19·5	15
16	D	271·5	May 8	Mar. 14,	11	6	July 2,	8	5	109	20	59	268	9	50	20·7	16
17	W	280·0	June 3	May 6,	8	40	July 2,	8	26	56	23	46	139	9	50	20·2	17
18	W	295·9	June 15	May 15,	9	38	July 16,	7	33	61	22	55	151	9	50	20·6	18
19	D	300·5	May 8	Mar. 14,	12	5	July 2,	8	41	109	20	36	268	9	50	16·9	19
20	D	313·7	June 26	June 7,	9	11	July 16,	8	9	38	22	58	95	9	50	24·2	20
21	W	339·5	May 23	April 16,	8	9	June 30,	8	46	75	0	37	183	9	50	19·6	21
22	D	354·9	May 14	April 16,	8	19	June 12,	8	20	57	0	1	139	9	50	24·6	22
23	W	123·9	June 15	May 14,	9	7	July 17,	8	30	63	23	23	156	9	50	26·8	23

In the second column "D" means Dark spot, "W" White spot.

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Notes.

1. Five observations. The spot was very dark and distinct, and coincided in position (and very nearly in rate of motion) with that of the zero meridian of system 1.

2. Five observations. Spot fairly conspicuous, and moving at nearly same rate as preceding.

3. Five observations. This object apparently gave the longest period of all the equatorial spots, but it was only followed during forty-eight days, which is hardly long enough for exact results.

4. Nine observations. A well-observed object and one of the most definite of its class.

5. Fourteen observations. In June and July this spot became remarkably brilliant, and was certainly more conspicuous than any other marking of similar character near the equator.

6. Eleven observations. Spot well defined, and its identity on different nights satisfactorily assured.

7. Very few observations were made, but the period derived is in good agreement with Nos. 6 and 8.

8 and 9. Seven and eleven observations. These spots, like Nos. 4 and 5, were of very pronounced type and observed sufficiently often to render identification quite certain. They moved slowly as compared with many other of the markings in the same latitude.

10. Only three observations were made, but there is little question that the same object was seen on each occasion.

11. Six observations. This object moved much faster than the foregoing, and apparently passed over it in May, but there is some doubt as to its identity.

12, 13, and 14. Few observations were obtained, though the objects were fairly conspicuous.

15 and 16. Nine and eleven observations. A well-defined pair of spots, of which an adequate number of transits were secured. They moved at nearly the same rate as the equally well observed pair of spots Nos. 4 and 5, but much swifter than Nos. 8 and 9.

17 and 18. Three and five observations. This pair apparently rotated with a velocity uniform with the preceding. They were, however, insufficiently observed, though there seems no reason to question their identification.

19. Six observations. This spot moved very rapidly, and at an irregular rate. Its velocity appears to have been greatest between May 5 and June 7.

20. Five observations. This object apparently moved much slower than the dark spot preceding it or the white spot which followed it.

21 and 22. Four observations were obtained of these objects. The former was very brilliant at times, and occasionally showed itself in the division between the N. and S. sides of the great S. equatorial belt. Its variations of aspect were remarkable and occurred at very short intervals.

23. This spot was recorded on only a few occasions, but it occupied a special position, breaking into the N. equatorial belt. Its rate of motion, being generally consistent with that of the other spots situated on the N. side of the great S. belt, sufficiently proves that the same current prevailed over a considerable zone in the equatorial region of the planet.

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The Great Red Spot on Jupiter. By W. F. Denning.

In *Nature* for 1898 August 4 I made some general comments on the associations and rate of motion of this remarkably durable object. Having been further examining the evidence bearing on the early history of the spot, it may be interesting to refer to some of the descriptions of this object in and since 1869, and then to give a table of the varying rotation period it has exhibited during 29 years. I have grouped the observations into periods of about three years, and have selected what appeared to be the most accurate. Though the times of transit had, in several cases, to be estimated from sketches they are believed to be fairly good, as they were carefully checked by other observations made at nearly the same period. Everything lends countenance to the view that the large brick-red spot detected by Russell, Pritchett, and Dennett in 1878 July, and by Tempel, Niesten, and others in the following month, was identical with the object described and figured by Gledhill in 1869 November 14 to 1870 March 29, and on 1871 December 1; by Mayer in 1870 January 5; by Knobel, Birmingham, Pratt, Terby, and Browning in the early months of 1872; by Lord Rosse and Dr. Copeland, 1872 December 31 to 1873 April 10; by Russell and Bredichin in the summer of 1876; and by other observers at various times. True the spot was not continuously visible (or, if so, must have curiously eluded notice), and before 1878 it appears to have been much involved in the brighter material floating in the upper regions of the Jovian atmosphere. But the latitude of the spot, the general size and form of it, the rate of its rotation period, its colour, and the peculiar shouldering of the S.S.[*] equatorial belt, S. of its preceding and following ends, are all very significant features, and leave no reason to doubt that Gledhill's ellipse, first seen in 1869 November 14, was really the forerunner of the red spot, then perhaps in an incipient stage, and certainly not nearly so well developed as when Lord Rosse and Dr. Copeland rediscovered and followed it, on the last day of 1872 and during the early months of 1873, with the 6-foot reflector at Parsonstown.

1869 November 14 to 1870 March 29. The great southern ellipse was a fine object, and easily seen every clear night. It lay between the S.S. equatorial belt and the S. temperate belt. Its eastern end was the darkest part of it. It was followed up to 1870 March 29, and its transits or approximate positions relatively to the central meridian were noted on twenty-two nights. J. Gledhill ($9\frac{1}{3}$-inch refractor), *Astronomical Register*, vol. viii. p. 81, &c.

1870 January 5. "A great elliptical ring observed in the

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[*] This term is adopted for brevity to distinguish the dark belt forming the southern side of the southern equatorial double belt.